The Role of Ecology in the Design of a Health Care System

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The weight of evidence does not support the hypothesis that the health status of the population is largely dependent on the quality and quantity of its medical services. Evidence to test this hypothesis is presented in a conceptual model of the relationship between health and disease and their care systems, suggesting that medical care is largely unrelated to the health status of the population.

Examples of disease trends and distribution are presented to support the thesis that ecology is the primary determinant of the health status of the population

Data from selected epidemiological studies point to poverty and air pollution as key factors in determining the pattern of mortality in the urban eco-system.

There is a widespread assumption in the medical profession and, indeed, among the lay public, that the health status of any community is largely a function of the quality and quantity of medical services available to it. Thus, if medical care services are meager or undeveloped, it is often assumed that the health status of the population is also less favorable and that this undesirable situation can be remedied by simply improving these services with respect to their quality, quantity, and distribution. The existence of contrary evidence is usually not considered.

In this paper we shall discuss several interrelated subjects which bear upon this assumption. First, a conceptual model of the relationship between health and disease and their care systems will be presented. This model forms the basis for the contention that medical care is largely unrelated to the health status of the population. Second, some examples of disease trends and distributions which support the thesis that the whole of ecological relationships is the most important determinant of health status will be considered. Finally, data from epidemiological studies carried out in Buffalo, New York, and its environs will be presented which point to poverty and air pollution as key factors in the urban ecosystem which determine its pattern of mortality. The implications of this for planning the most effective points of intervention for improving health status will then be discussed.

However, before considering the health-disease spectrum model, it is important to emphasize that when we assert that medical care is largely unrelated to the health status of the population, we do not mean to imply that the

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Submitted August 21, 1970.

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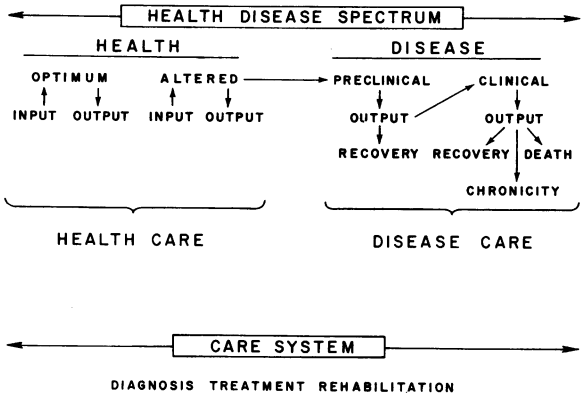

Chart 1.—Health-disease spectrum and its care system.

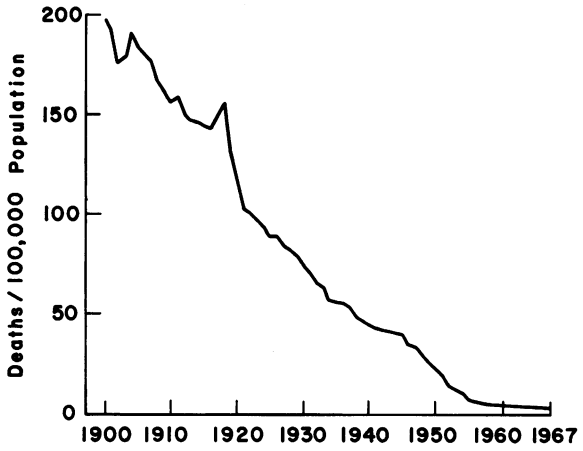

Chart 2.—Annual age adjusted tuberculosis death rates per 100,000 population, death registration states of the U.S., 1900-1967.[1,2] (Adjusted to the age distribution of the U.S. population in 1940.)

sick and injured should not have ready access to high quality medical care. We are committed to the concept that excellent medical care should be available to all. However, equating care of the sick with the state of health of the population is probably fallacious.

The model is presented in Chart 1. Health and disease are viewed as a continuum varying from optimum health at one end through altered health and preclinical disease to clinical disease at the other. In general, there is a tendency for individuals to move to the right in the model as age increases. Nevertheless, there is some leftward movement, particularly early in life and for some specific conditions such as childhood asthma, eczema, and certain types of myopia. If the model is generally valid, it is apparent that when an individual moves into the preclinical phase of the spectrum, he is already diseased. For many conditions, the subsequent clinical course is predetermined. These include many cancers, diabetes, stroke, and coronary artery disease. At best, in these diseases, the individual may be held at the preclinical phase or in chronicity. Incidentally, the acute infectious diseases of viral etiology have long been recognized as following a predetermined course once they have reached the preclinical phase.

The health and disease care system consisting of diagnosis, treatment and rehabilitation can be brought to bear on this spectrum at any point. When effectively used in health, this results in disease prevention and optimum wellness. When effectively used in disease, it results in recovery or arrest of the disease process. Unfortunately, diagnosis, treatment and rehabilitation have been developed and applied principally to the preclinical and clinical portions of the spectrum, and thus have had little effect on the health portion. No matter how vigorously they are applied in this area, the output of altered health states will continue to feed the ranks of the diseased.

There are inputs into the health side of the spectrum which lead to either optimum or altered states of health. Several examples come quickly to mind. Trace amounts of fluoride ion (1 to 2 parts per million) in drinking water bring about formation of tooth enamel which is particularly hard and resistant to caries. Conversely, lack of trace amounts of iodine in the food of a population causes altered thyroid function and ultimately substantial clinical manifestation of thyroid disease. Much is known about these inputs and outputs but areas of ignorance remain large.

Let us now turn to some examples of disease trends which can be interpreted in support of the thesis that ecology, defined as the general interaction of man and his environment, is the primary determinant of the health status of the population.

In 1900 tuberculosis was the second leading cause of death in the United States with a rate of 200 deaths per 100,000 population. By 1967, the rate had declined to 3.0 deaths per 100,000 population. This change is reflected in Chart 2. Of course, cases still occur, but the curves of infection as determined by tuberculin testing,

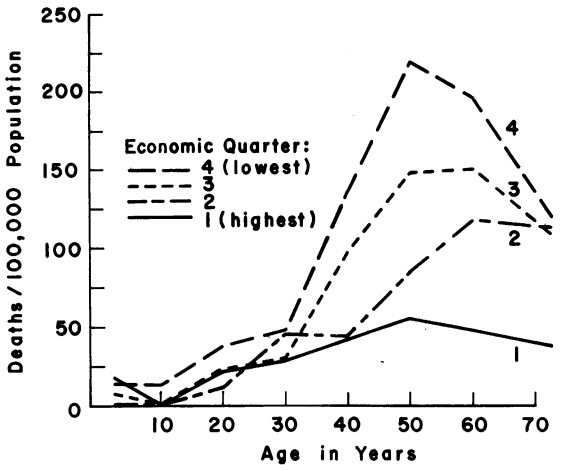

Chart 3.—Average annual tuberculosis death rates per 100,000 population for white men by age and by economic quarter of census tract of residence, Buffalo, New York, 1939-1941.[3]

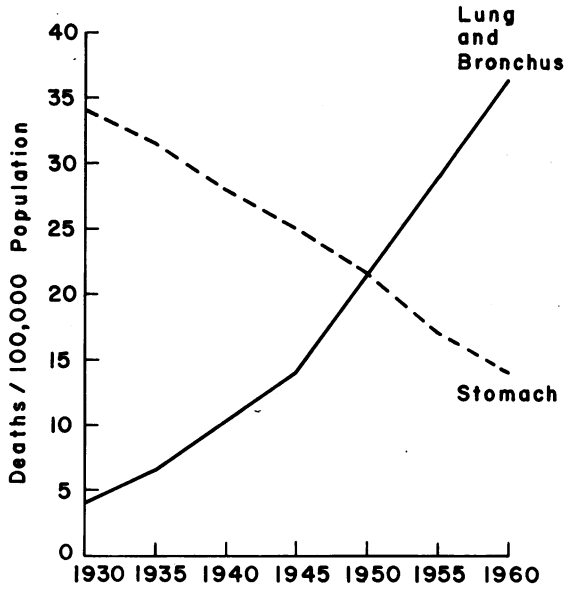

Chart 4.—Annual age adjusted death rates per 100,000 population for cancer of the lung and bronchus, and for cancer of the stomach, white men in the United States, 1930-1960.[4] (Adjusted to the age distribution of the U.S. population in 1950. Includes international classification of diseases code numbers 162.1-163 and 151, 1955 revision.)

and of incidence as determined by case reporting have generally paralleled the curve of mortality. Can this trend be attributed to the vast case-finding and treatment program carried out during the past 70 odd years since the first tuberculosis sanitarium on this continent was established at Saranac Lake? We do not think so.

Collapse therapy was introduced in the decade of the thirties and chemotherapy in the fifties. The latter may have had some slight effect on increasing the downward trend of mortality, but one can see quite clearly in Chart 2 that the trend had been established well before the introduction of these means of treatment. But, one may argue, other measures such as isolation of patients were also being carried out.

The data in Chart 3 are from Buffalo, New York, and were published by Terris in 1948.[3] They show that for white men there was a large difference in tuberculosis mortality experience dependent on economic status. White men in the middle years of life living in the lowest economic quartile areas had rates more than four times as high as those in the highest economic quartile areas. That this was not a function of medical care is supported by two facts. First, tuberculosis diagnosis and treatment had been available in upstate New York for everyone regardless of ability to pay for some years before 1940 and, second, mortality rates among women in all economic groups in Buffalo in 1940 were uniformly low. Terris concluded that the general life-style or experiences of men in various social strata determined their tuberculosis mortality. A corollary conclusion was that some contributing occupational stresses were of major importance.

Consider now two kinds of cancer which, having developed to the preclinical stage, almost invariably progress to a fatal outcome regardless of treatment. They are cancer of the lung and cancer of the stomach. As seen in Chart 4, the trend of mortality from these cancers between 1930 and 1960 shows a striking decrease for gastric cancer and a tremendous increase for lung cancer.[4] As to lung cancer, there is no more doubt that cigarette smoke is the vehicle for a chemical carcinogen(s) than there is that sewage-contaminated drinking water will produce gastroenteritis. If we are interested in affecting the death rate from the first cancer cause of death in American men, it is apparent where we should concentrate our efforts.

But what about cancer of the stomach? Why has it decreased so greatly? There is no generally accepted explanation. Many if not most surgeons would agree that the five-year survival rate for this disease has remained essentially unchanged during these years. Misdiagnosis of cancer of the pancreas and liver cannot account

Table 1.—*Average annual stomach cancer death rates per 100,000 population according to economic level of census tract of residence, white men and women 50-69 years of age, Buffalo, New York and environs, 1959-1961.[5] (Includes international classification of disease code number 151, 1955 revision.)*

Economic Level of Census Tract of Residence*	Death Rate per 100,000 Population	
	Men	Women
1 (low)	77	28
2	50	21
3	44	28
4	33	12
5 (high)	20	11
Total	42	19

*Based on median family income for each census tract: 1 = $3,005-$5,007; 2 = $5,175-$6,004; 3 = $6,013-$6,614; 4 = $6,618-$7,347; 5 = $7,431-$11,792.

Table 2.—*Average annual death rates from all causes per 1,000 population according to economic and air pollution levels of census tract of residence, white men 50-69 years of age, Buffalo, New York and environs, 1959-1961.[7]*

Economic Level of Census Tract of Residence*	Air Pollution Level of Census Tract of Residence#				
	1 (low)	2	3	4 (high)	Total
1 (low)	....	36	41	52	43
2	24	27	30	36	29
3	....	24	26	33	25
4	20	22	27	....	22
5 (high)	17	21	20	....	19
Total	20	24	31	40	26

....: indicates no census tract with these characteristics.

*See footnote Table 1.

#Based on average suspended particulate levels: 1 = < 80 micrograms per cubic meter per 24 hours; 2 = 80-100 μg/cu m/24 hr; 3 = 100-135 μg/cu m/24 hr; and 4 = > 135 μg/cu m/ 24 hr.

for much of the change. There is no good explanation for the decline which has shifted this disease from the first cancer cause of death among men to the fourth or fifth. About all that can be said is that the improvement cannot be attributed to improved medical care. However, in view of the tuberculosis story we might inquire as to whether all economic classes of the population have shared equally in the declining morbidity and mortality from this disease.

The data from Buffalo in Table 1 indicate a very strong inverse association between economic status and stomach cancer mortality.[5] In fact, death rates are approximately three times as great in the lowest economic group as in the highest, even for women whose rates are less than half those for men. Since medical care of patients with clinical cancer has not improved survival chances, we cannot assume that this explains the lower rates for the economically favored. Rather, it may be inferred that environmental factors of some kind are exerting a strong influence and that some change (or changes) in the environment not shared by all economic classes has produced the downward trend noted in Chart 4. Incidentally, the data have been examined to see whether ethnicity, particularly Polish birth or ancestry, previously shown to be associated with excess stomach cancer,[6] could have accounted for the distribution. This has been ruled out.[5]

The case for ecology is hardly made by review of mortality from two diseases. But, there are many other examples which could be cited from morbidity as well as mortality data, and no catalogue could be complete. The two examples cited thus far have demonstrated the point that for these major diseases the trends of occurrence are independent of the specific measures taken to treat them. Of the first ten causes of death in the United States, we would include six for which vigorous application of the disease care system has little or no effect on prevalence and incidence in the population. These are coronary artery disease, malignant neoplasms (with a few notable exceptions), cerebrovascular disease, accidents, general arteriosclerosis, and diabetes.

Now let us turn to a more specific consideration of the importance of poverty and another environmental factor, air pollution, as determinants of mortality in an urban population. The data are from the Erie County, New York, Air Pollution Study and include white men dying in the area in the pericensal period 1959-1961.[7] We can first examine the effect of classifying the population according to economic status, and then according to suspended particulate air pollutants, each for the census tract of residence at time of death.

Not unexpectedly, it may be seen by examining the last column of Table 2 that men living in the lowest economic areas have death rates twice that of those living in the highest economic areas. Perhaps less expected are the rates in the bottom row of this table which show that men living in the highest air pollution areas also have death rates twice that of those living in the lowest air pollution areas.

Since it might be expected that economic status and air pollution level of each census

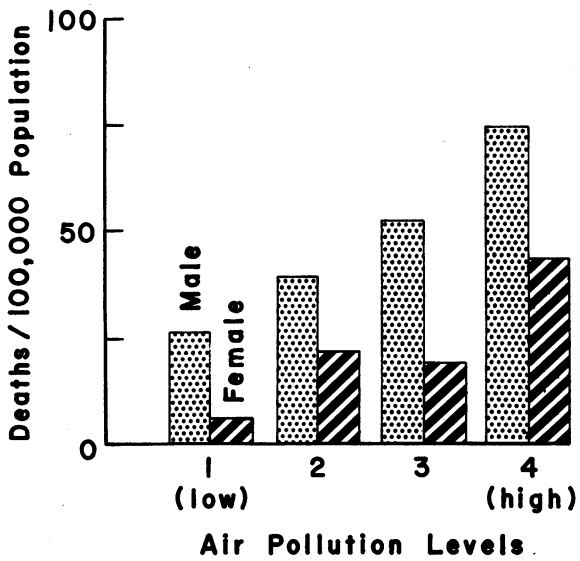

Chart 5—Average annual stomach cancer death rates per 100,000 population by air pollution level for white men and women 50-69 years of age in the middle economic level, Buffalo, New York and environs, 1959-1961.[5] (Includes international classification of diseases code number 151, 1955 revision. The middle economic level refers to combined economic groups 2-4 as described in Table 1.)

tract might be inversely associated, that is, tracts of low economic status might have high air pollution, and vice versa, the data were analyzed with each factor controlled. When this was done it became apparent that in this age group both air pollution and economic status were independently associated with total mortality—that is, in each row of Table 2 mortality increased as air pollution increased, and in each column of the table mortality decreased as economic level increased. However, it was most interesting to note that in the highest economic grouping, the air pollution effect was minimal, while in the lowest air pollution area, the economic effect was minimal. The combination of highest air pollution exposure and lowest economic status was associated with a death rate three times that in the area of highest economic status and lowest air pollution. These findings were replicated among women, leading to the conclusion that exposure to occupational hazards was not the primary factor determining the distribution. An examination of census data with respect to population mobility in the various subgroups provided no evidence that differential migration could account for the trends.

These striking findings are hard to explain on the basis of quality, quantity, and availability of medical care. Their consistency over all levels of economic status and air pollution argues for their validity. Furthermore, if they are valid they have profound implications for planning. Before turning to this final issue, however, we will return briefly to the stomach cancer problem.

Stomach cancer mortality has already been shown to have a strong inverse association with economic status suggesting an environmental causal agent. The possibility that this factor might be suspended particulate air pollution was examined in the Erie County Air Pollution Study.[5]

The analysis indicated a strong association between suspended particulate air pollution and gastric cancer. Of particular interest was the fact that when air pollution was taken into account, much of the economic gradient disappeared, leading to the hypothesis that air-borne carcinogens may be an important cause of this cancer. The inference is that as coal smoke air pollution decreased over time due to discontinuation of use of coal for heating and locomotion, the overall death rate from cancer of the stomach fell although a differential mortality between areas of relatively more particulate pollution and areas with less remained. Presumably, large particle carbonaceous soot is the source of the carcinogen. The rates in Chart 5 summarize the data for the middle economic groups and show, for men, a three-fold difference between the highest and lowest air pollution areas. For women, the difference is even greater, with the highest air pollution area experiencing a rate almost nine times as high as the lowest pollution area. The difference in risk between males and females can be hypothesized to be due, at least in part, to increased exposure of males to an unidentified carcinogen possibly present in various occupational settings.

Let us now return to the health disease spectrum model and consider the implications of the foregoing to health and disease care planning. First, it is necessary to recognize the uncomfortable fact mentioned earlier—that relatively little that is done at the preclinical and clinical levels has a real effect on health. This is not to say that disease care isn't important, but it does suggest that priorities should be adjusted if the overall objective is improving the health of the people. At present most planning efforts are channeled in the direction of

disease care. The bulk of our medical resources —manpower, physical plant, research, and, of course, money—is directed here. As a matter of equity and humanity we need to continue to improve, expand, and redistribute these efforts, but we must recognize the inherent limitations of this action.

Turning to the health side of the model, it seems that a strong case can be made that the circumstances surrounding the condition of poverty in our society are powerful determinants of altered health status and eventually of disease. One element of this may well be air pollution. The disease-distributions presented here give strong support to the hypothesis that improvement of economic status will of itself produce substantial health effects. However, when we are able to identify specific components of the environment which affect health we may increase our potential for limiting the inputs which produce altered health status.

Consider the following. When we construct a disease classification based on a broad class of causes—for example, infectious diseases—we are able to orient ourselves readily to consideration of mechanisms for control. However, when we think that a disease has a multifactorial causation or when we feel that we do not understand its specific causal mechanism sufficiently well to classify it on this basis, we become confused. The fact that infectious diseases have a wide variety of clinical and pathological manifestations and, indeed, causal agents, doesn't give much difficulty. But to suggest a classification of smoking diseases or poverty diseases does. If we classified lung cancer, bladder cancer, chronic bronchitis and emphysema, and perhaps even coronary artery disease together as smoking diseases and spoke of them as such, we might be further along the way to their control.

We would like to emphasize the fact that the precise factors in the environment which affect many particular physiological functions or human host-disease relationships are not known. Tuberculosis may well have been controlled by manipulation of the environment inadvertently and we may be accomplishing the same thing with gastric cancer. When typhoid fever and cholera were largely controlled in Europe and America by sanitation of water supplies, the cholera vibrio and typhoid bacillus had not yet been isolated. We submit that very substantial changes in the direction of decreases in the major diseases of urban society will occur if economic status is improved and the environment is recognized for what it is, a major determinant in the health-disease spectrum.

But words are cheap. And a lot has been written and spoken about poverty, ecology, and pollution recently. Some, however, recognized these relationships before, and spoke out quite clearly in the distant past. We close with a quotation from a paper entitled "On Airs, Waters, and Places" by Hippocrates:[8]

> . . . when one comes into a city to which he is a stranger, he ought to consider . . . the waters which the inhabitants use, whether they be marshy and soft, or hard, and running from elevated and rocky situations, and then if saltish and unfit for cooking; and the ground, whether it be naked and deficient in water, or wooded and well watered . . . and the mode in which the inhabitants live, and what are their pursuits, and whether they are fond of drinking and eating in excess and given to indolence, or are fond of exercise and labor . . . For if one knows all these things well . . . he cannot miss knowing . . . either the diseases peculiar to the place, or the particular nature of the common diseases . . .

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